

Stock Assessment and Biological Characteristics of Burbot in Tolsona Lake, 2000

by
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Alaska Department of Fish and Game

Division of Sport Fish



Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition.

Weights and measures (metric)		General		Mathematics, statistics, fisheries	
centimeter	cm	All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.	alternate hypothesis	H _A
deciliter	dL			base of natural logarithm	e
gram	g	All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.	catch per unit effort	CPUE
hectare	ha	and	&	coefficient of variation	CV
kilogram	kg	at	@	common test statistics	F, t, χ^2 , etc.
kilometer	km	Compass directions:		confidence interval	C.I.
liter	L			correlation coefficient	R (multiple)
meter	m	east	E	correlation coefficient	r (simple)
metric ton	mt	north	N	covariance	cov
milliliter	ml	south	S	degree (angular or temperature)	°
millimeter	mm	west	W	degrees of freedom	df
		Copyright	©	divided by	÷ or / (in equations)
		Corporate suffixes:		equals	=
		Company	Co.	expected value	E
		Corporation	Corp.	fork length	FL
		Incorporated	Inc.	greater than	>
		Limited	Ltd.	greater than or equal to	≥
		et alii (and other people)	et al.	harvest per unit effort	HPUE
		et cetera (and so forth)	etc.	less than	<
		exempli gratia (for example)	e.g.,	less than or equal to	≤
		id est (that is)	i.e.,	logarithm (natural)	ln
		latitude or longitude	lat. or long.	logarithm (base 10)	log
		monetary symbols (U.S.)	\$, ¢	logarithm (specify base)	log ₂ , etc.
		months (tables and figures): first three letters	Jan, ..., Dec	mid-eye-to-fork	MEF
		number (before a number)	# (e.g., #10)	minute (angular)	'
		pounds (after a number)	# (e.g., 10#)	multiplied by	x
		registered trademark	®	not significant	NS
		trademark	™	null hypothesis	H ₀
		United States (adjective)	U.S.	percent	%
		United States of America (noun)	USA	probability	P
		U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)	probability of a type I error (rejection of the null hypothesis when true)	α
				probability of a type II error (acceptance of the null hypothesis when false)	β
				second (angular)	"
				standard deviation	SD
				standard error	SE
				standard length	SL
				total length	TL
				variance	Var
Weights and measures (English)					
cubic feet per second	ft ³ /s				
foot	ft				
gallon	gal				
inch	in				
mile	mi				
ounce	oz				
pound	lb				
quart	qt				
yard	yd				
Time and temperature					
day	d				
degrees Celsius	°C				
degrees Fahrenheit	°F				
hour	h				
minute	min				
second	s				
Physics and chemistry					
all atomic symbols					
alternating current	AC				
ampere	A				
calorie	cal				
direct current	DC				
hertz	Hz				
horsepower	hp				
hydrogen ion activity	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

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BURBOT IN TOLSONA LAKE, 2000**

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ABSTRACT

Abundance, mean CPUE, and length composition were estimated for the population of burbot *Lota lota* in Tolsona Lake in Southcentral Alaska. Sampling occurred in June 2000. Bootstrapped mean catch per unit of effort of fully recruited burbot (450 mm total length and larger) per 48-hour set was 6.25 (SE = 0.74) in Tolsona Lake, the highest level of CPUE for this lake since 1986. Abundance during 1999 of fully recruited burbot estimated with mark-recapture experiments was 1,078 (SE = 254) in Tolsona Lake. Estimated annual survival rate for fully recruited burbot in Tolsona Lake was 54.4% (SE = 10.8%) between 1998-1999. Estimated length composition indicated few large (>675 mm TL) burbot present, but due to strong recruitment in recent years the average size of burbot in Tolsona Lake is increasing. Water quality measurements in Tolsona Lake were below critical indicator levels for temperature, dissolved oxygen, pH, and water clarity. The historic abundance, harvests and management strategy of Tolsona Lake are discussed in the context of burbot fishery management.

Key words: Burbot, *Lota lota*, abundance, length composition, catch-per-unit effort, hoop traps, mean length, survival rate, recruitment, fishery management.

INTRODUCTION

Historically, the lakes of the Upper Copper/Upper Susitna management area (UCUSMA; Figure 1) supported the largest burbot fishery in the state. Harvests from the UCUSMA averaged over 8,000 burbot or 57% of the statewide burbot harvest from 1977 – 1988 (Taube and Sarafin 2001). Harvest from the fishery peaked in 1985 when over 19,000 burbot were harvested from the UCUSMA, accounting for 71% of the statewide burbot harvest (Mills 1986; Figure 2). The Tyone River drainage (consisting of Lake Louise and Susitna and Tyone lakes) supported over half of the burbot harvested in the Glennallen area (UCUSMA) prior to 1987. Concerns about overexploitation resulted in the Alaska Department of Fish and Game (ADF&G) initiating research in 1986 to collect basic life history information necessary to assess stock status and to estimate sustained yield of burbot in interior Alaskan lakes. In 1988, the Board of Fisheries adopted a lake burbot management plan into regulation (5 AAC 52.045). This plan directs the ADF&G to manage burbot stocks in lakes of the UCUSMA to permit maximum sustainable harvests on healthy stocks, rebuild depressed stocks, and maintain opportunity for anglers to participate in the fishery.

ADF&G has managed the UCUSMA burbot fisheries through bag limits, gear restrictions, and lake closures. Since 1988, bag and possession limits have been reduced to 5 burbot per day on most lakes, and 2 burbot per day on some heavily fished road-accessible lakes. The use of setlines has been prohibited by emergency order in the Tyone River drainage and in Tolsona and Moose lakes from 1989 - 1991, and by regulation since 1991 in the entire UCUSMA. The fishery in Lake Louise was closed in 1988 due to continued declines in abundance of burbot. Lake Louise remains closed to burbot fishing since stock assessment indicates that the population stabilized but is not at historical levels. Hudson Lake was also closed in 1988, but stock assessment in May 1993 indicated the population had recovered sufficiently to open the lake to harvest in November 1993.

The Tolsona Lake population is the only burbot population in the UCUSMA assessed in 2000. The lake is 130 ha in area, has a maximum depth of 4 m, and an elevation of 625 m. There are numerous cabins and one lodge along the shore. No public recreational facilities are available. Arctic grayling *Thymallus arcticus*, longnose suckers *Catostomus catostomus*, and stocked rainbow trout *Oncorhynchus mykiss*, are sympatric with burbot. This burbot population has been

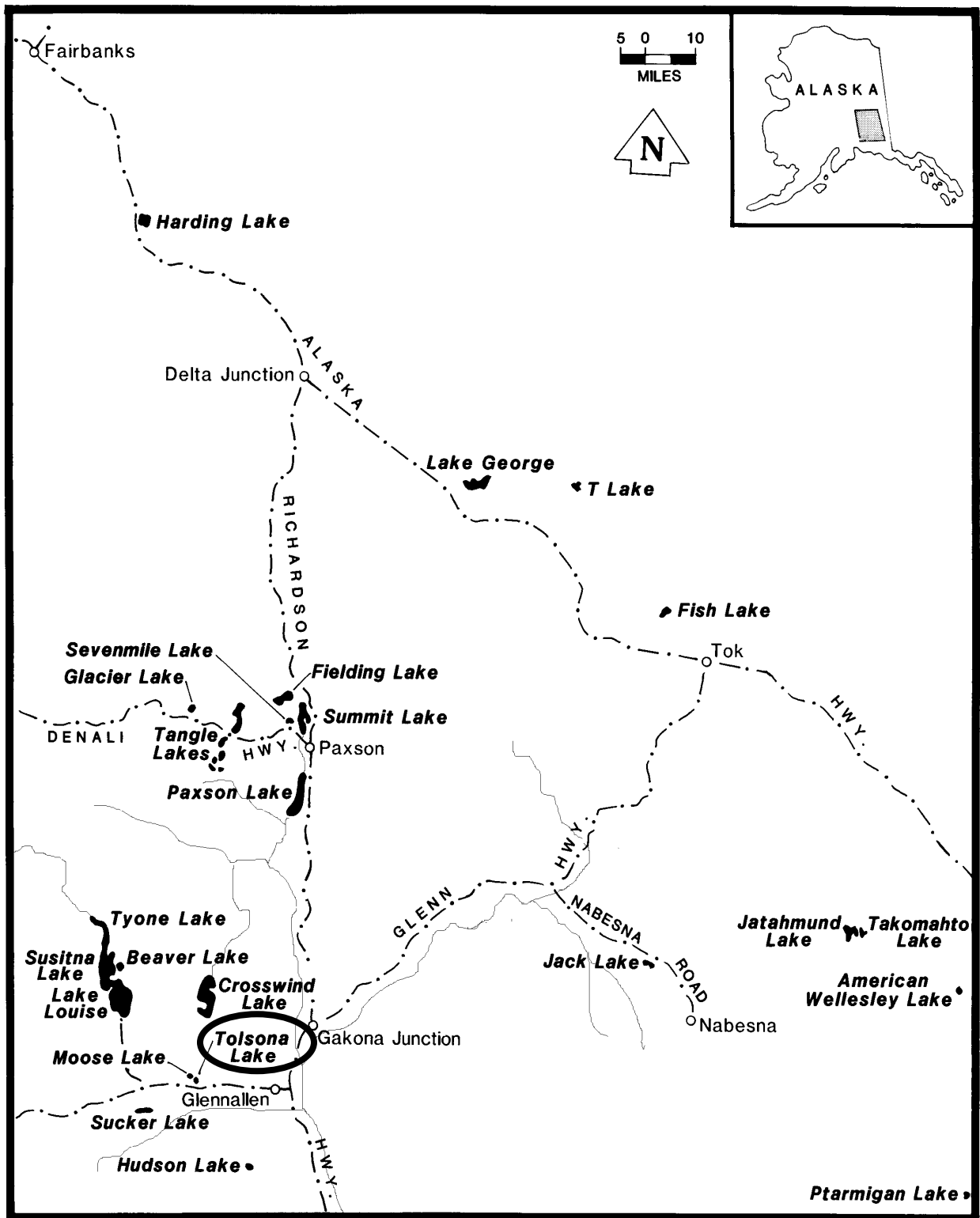


Figure 1.-Lakes of the UCUSMA that have supported burbot fisheries in the past.

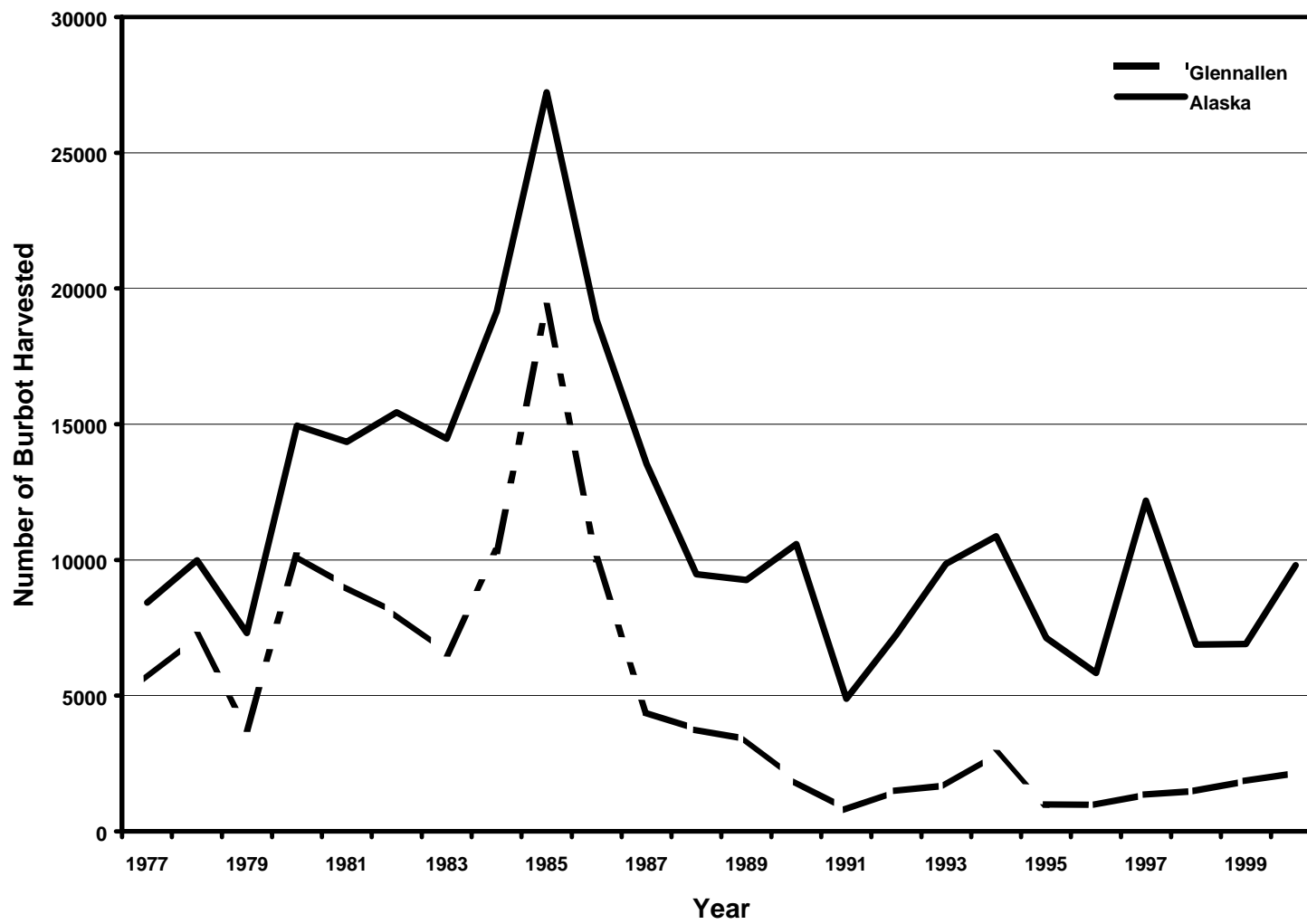


Figure 2.-Harvest of burbot in sport fisheries of the Glennallen Area (UCUSMA) compared to all burbot harvested in Alaska, 1977-2000.

assessed annually since 1986 as part of a long-term study on an exploited population (Parker et al. 1987-1989; Lafferty et al. 1990-1992; Lafferty and Bernard 1993; Taube et al. 1994, 2000; and Taube and Bernard 1995, 1999). In 1998, Tolsona Lake was closed to burbot fishing due to a dramatic decline in burbot abundance (Figure 3) and poor summer survival that occurred in 1996. This decline was likely due to a combination of factors, but high summer water temperatures may have contributed significantly to this decline. To date, Tolsona Lake remains closed, as the burbot population has not recovered to a level capable of sustaining expected harvests. In 2000, the burbot population in Tolsona Lake was sampled to estimate abundance, length composition, and mean catch-per-unit of effort (CPUE). In addition, data on water temperature profiles and water chemistry were collected.

The objectives for the project during 2000 were to:

1. estimate the length composition of burbot (≥ 450 mm TL) for each sampling event in Tolsona Lake;
2. estimate the abundance of burbot (≥ 450 mm TL) in Tolsona Lake;
3. estimate mean catch-per-unit of effort (CPUE) of burbot (≥ 450 mm TL) in Tolsona Lake; and,
4. develop an exploitation rate model based upon existing levels of harvest and abundance in area lakes.

Project tasks for 2000 were to:

1. collect temperature data to provide a temperature profile of Tolsona Lake during the open-water period;
2. collect water quality data at one-month intervals in Tolsona Lake from May through September; and,
3. collect dissolved oxygen measurements from Tolsona and area lakes during March.

METHODS

STUDY DESIGN

Burbot were captured in 3-m long baited hoop traps with 25-mm mesh net, set on the bottom as described in Bernard et al. (1991). Burbot ≥ 450 mm TL were fully recruited to this gear (burbot of this size are approximately 6 years of age and are usually sexually mature). Traps were positioned according to a systematic sampling design as described in Bernard et al. (1993) to minimize competition among the gear and cover the bottom of the lake. Sampling at Tolsona Lake occurred from 6-8 June 2000, immediately after the lake became ice-free, because this is the time where catch per set is maximized (Bernard et al. 1993). A set is defined as a single hoop trap soaked for 48 hours. Traps were systematically placed along randomly chosen transects across Tolsona Lake to produce 60 sets on the 130 ha lake. The Jolly-Seber model (Seber 1982) was used to estimate abundance of burbot in Tolsona Lake for 1999.

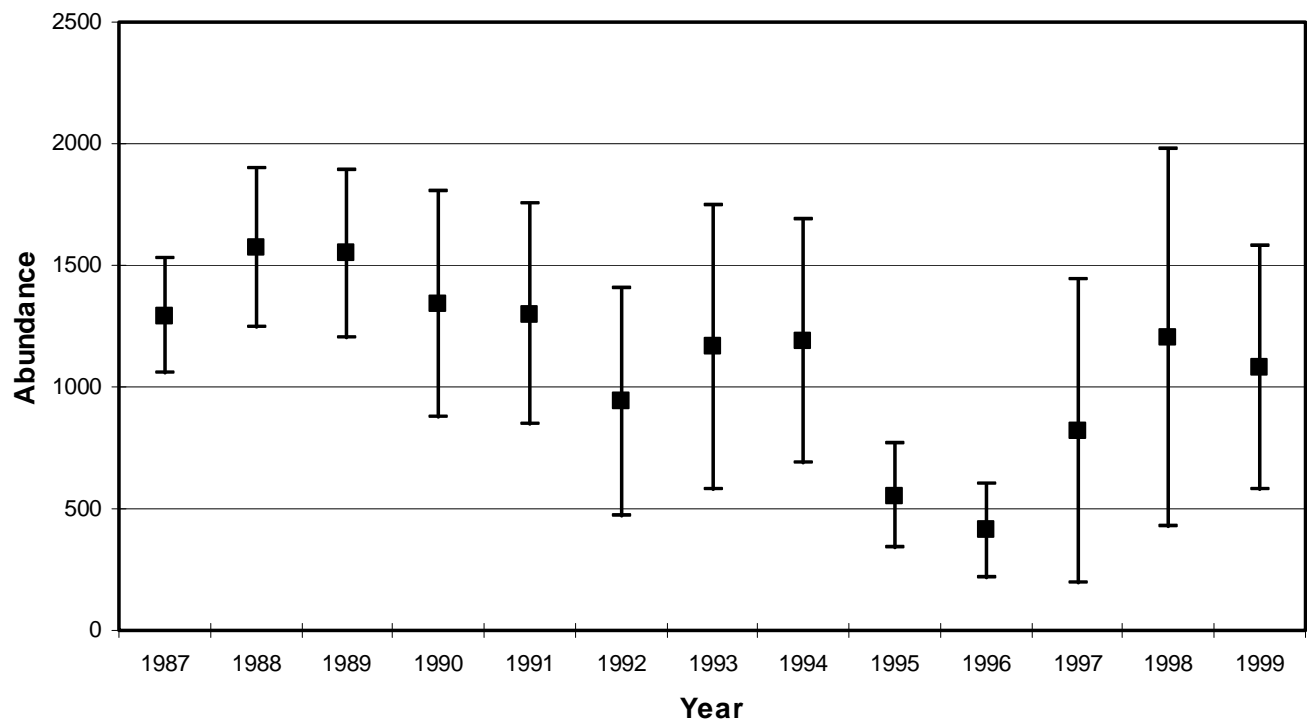


Figure 3.-Estimated abundance and 95% confidence intervals of fully recruited (≥ 450 mm) burbot in Tolsona Lake, 1987-99.

After lifting a hoop trap, the catch was emptied into a holding tank, and burbot were inspected for previous marks, tagged (if necessary), measured for total length (to the nearest 5 mm), and then returned to the lake. Each unmarked burbot was tagged with an individually numbered Floy tag inserted in the musculature beneath the dorsal fin. All tags were checked to insure that they were locked between the pterygiophores of the dorsal fin. Each burbot also received a second mark in the form of an opercular punch. This second mark was used to evaluate loss of Floy tags. The left ventral finclip (1998), right ventral fin clip (1999), and opercular punch (2000) have been used as secondary marks in a three-year rotation in Tolsona Lake. A recaptured burbot without a tag was recorded as being captured in the year in which the secondary mark was last used. Individual trap and associated catch information was recorded on standard hoopnet mark-sense forms (Heineman *Unpublished*). Trap information included the following: hoop trap number, location of set, depth of set, hour set and hour pulled, and number of fish caught by species. Tag number and color, secondary mark, and total length were recorded on the mark-sense form for each burbot caught in each set. In the event of sampling-induced mortalities, otoliths were extracted, and age was determined at a later date. Processing and reading of otoliths followed the procedures described by Chilton and Beamish (1982). Age information was added to the database record of each burbot aged.

Temperature and water quality data for Tolsona Lake were collected through the ice in April and during the open water period in June, August, and October 2000. Water clarity (determined by use of a secchi disk), conductivity and pH were collected for comparison to data collected in 1993 during a University of Alaska-Fairbanks research project (Simpson 1997). These data indicated changes in water and environmental conditions at Tolsona Lake. Measurements of water temperatures and dissolved oxygen were compared with published thresholds for physiological stress in and survival of burbot (Scott and Crossman 1973).

DATA ANALYSIS

Abundance, survival rate, and recruitment statistics were generated for the burbot population in Tolsona Lake (through 1999) with the Jolly-Seber model (Seber 1982) using the computer program JOLLY (Model A) developed by Brownie et al. (1986; see Pollock et al. 1990 for a description of JOLLY). Model A is the most general form of the Jolly-Seber model and assumes capture probabilities and survival rates varied over time. Individual burbot captured more than once in 2000 were only considered captured once in this analysis. Conditions needed for producing accurate statistics with the Jolly-Seber model were:

1. all burbot had the same probability of capture during each sample event (probability of capture can vary among events) or marked burbot completely mixed with unmarked burbot between sample events;
2. no marks were lost between sample events;
3. marked burbot behaved (enter traps) similar to unmarked burbot;
4. marked burbot had the same mortality rate as unmarked burbot; and
5. immigration and emigration were permanent.

Because burbot < 450 mm TL were not fully recruited to the sampling gear used in this project (Bernard et al. 1991), statistics were only generated for burbot \geq 450 mm TL. The probability of capturing extremely large burbot (> 900 mm TL) was less than the probability of capturing

burbot < 900 mm TL in the hoop traps used in this project (Bernard et al. 1991). This was not considered significant, however, since there are few burbot larger than this size in this population. Traps were distributed uniformly to promote mixing and to homogenize the probability of capture of burbot across Tolsona Lake. Over the span of a year, burbot should completely mix throughout Tolsona Lake. Double marking of burbot (tag and finclip) permitted correction of bias in estimates due to loss of tags. Previous studies indicated little change in behavior (trap happiness or trap shyness) of captured burbot (Bernard et al. 1991). Although an intermittent stream connects Moose and Tolsona lakes, only one of several thousand burbot recaptured from 1986 - 2000 was recaptured in a lake in which it was not marked.

Mean CPUE was estimated for fully and partially (< 450 mm TL) recruited burbot in Tolsona Lake from a two-stage sampling design with transects as first-stage units and sets along transects as second-stage units (Sukhatme et al. 1984). Although all transects had an equal probability of being included in a sample event, they were of different lengths depending upon the shape of the lake. Under these conditions, the unbiased estimate of mean CPUE was:

$$\overline{CPUE} = \frac{1}{n} \sum_{i=1}^n \frac{1}{m_i} \sum_{j=1}^{m_i} \omega_i c_{ij} \quad (1)$$

where:

c_{ij} = catch of burbot from the j th set on the i th transect;

n = number of transects;

■

m_i = number of sets sampled on the i th transect;

\bar{m} = mean number of sets sampled across all transects;

$\omega_i = M_i / \bar{M}$;

M_i = maximum number of possible sets on the i th transect; and

\bar{M} = mean number of possible sets across all transects.

Although the M_i and \bar{M} are unknown, the m_i and \bar{m} were used as substitutes because both M and m are directly related to the length of transects. Thus $\bar{\omega}_i = m_i / \bar{m}$ was used to estimate ω_i . Because few burbot enter traps during daylight (Bernard et al. 1991), catches were not adjusted for the few hours deviation in soak times from the standard 48 h for most sets. A two-stage, resampling (bootstrapping) procedure (Efron 1982; Rao and Wu 1988) was used to generate an empirical distribution of mean CPUE for each sample event from which variance of mean CPUE and bias from using $\bar{\omega}$ were estimated. In resampling procedures, sets were chosen randomly within each transect although the original selection of sets was systematic. Systematically drawn data can be treated as randomly drawn with little concern for bias in the resultant statistics only so long as these data are not autocorrelated or follow a trend (Wolter 1984). Analysis of data from surveys has revealed no meaningful trends or autocorrelations among catches along transects (Bernard et al. 1993). Estimates of mean CPUE for two groups of burbot (≥ 450 mm

and < 450 mm TL) were calculated for each sample event using procedures described in Bernard et al. (1993). The computer program RAOWU.EXE was used to estimate mean CPUE, approximate its variance, and estimate inherent bias in the estimate according to a two-stage bootstrap procedure based on a model in Rao and Wu (1988). Individual burbot captured more than once in 2000 were considered different fish each time captured in calculation of mean CPUE. Conditions for the accurate calculation of mean CPUE as an index of abundance were:

1. gear did not compete for burbot;
2. burbot did not saturate the gear; and,
3. gear was not size-selective.

Bernard et al. (1993) showed that the spacing of sets used in this project is sufficient to avoid competition among gear for burbot and that saturation of gear by burbot is negligible. Because hoop traps as fished in this project are size-selective for burbot (Bernard et al. 1991, 1993), mean CPUE for only fully recruited burbot was considered as a valid index of abundance.

RESULTS AND DISCUSSION

Estimated abundance of burbot (≥ 450 mm TL) for 1999 at Tolsona Lake was 1,078 (SE = 254), which was the second largest since spring 1994 (Table 1; Figure 3). Estimated recruitment from 1998 to 1999 was 423 (SE = 367), which was the third largest since 1992 to 1993. However, numbers of large fish (> 675 mm FL) in Tolsona Lake remain low (Figure 4). Estimated density of fully recruited burbot in 1999 was 8.29 burbot/ha in Tolsona Lake (Table 2). Of the fully recruited burbot released in previous years and recaptured in 2000, 7% were recovered without tags. Four of the 88 fish recaptured from previous years were identified by secondary marks. All secondary marks were right ventral, which was the secondary mark used in 1998. The mark-recapture history for Tolsona Lake is found in Appendix A.

Mean CPUE of fully recruited burbot in Tolsona Lake in 2000 was 6.25 (Table 3), which was the second highest since sampling began in 1986. Mean CPUE of 7.15 was reported from sampling in fall 1986 and 6.15 in spring 1987 (Table 4; Parker et al. 1987 and 1988). In general, mean CPUE estimates follow trends in abundance, and with this in mind, it is anticipated that abundance was also greater in 2000. Statistics concerning mean CPUE for partially recruited burbot are listed in Table 3. The frequency of sets by depth and average catch of burbot by depth for sampling in 2000 is shown in Appendix B.

Water temperature was greatest during sampling in August and dissolved oxygen was greatest during sampling in June (Table 5). In general, both temperature and dissolved oxygen levels decreased with depth during open-water periods. During sampling in April, when ice and snow cover was still present on the lake, water temperature increased with depth. Dissolved oxygen was below the critical level at depths 2.0 m or greater during this same period. Water level in Tolsona Lake remained stable in 2000, which was likely responsible for water temperatures that did not exceed critical levels for burbot.

Table 1.-Estimates of abundance, survival rate, and recruitment for fully recruited (≥ 450 mm TL) burbot by date residing in Tolsona Lake.

Date	Days between events	Abundance			Survival Rate %		Recruitment	
		Estimate	SE	CV %	Estimate	SE	Estimate	SE
9/26/86		1,901 ^a	120	21.6				
	235				60.0	4.6	138	209
6/25/87		1,291	120	9.3				
	335				74.3	6.6	616	136
5/26/88		1,571	165	10.5				
	95				77.1	8.8	68	124
9/01/88		1,280	155	12.1				
	263				73.6	9.2	607	134
5/24/89		1,549	176	11.4				
	110				97.2	15.8	157	157
9/13/89		1,663	273	16.4				
	251				47.3	9.4	553	159
5/24/90		1,340	237	17.7				
	104				38.4	6.7	93	76
9/07/90		608	92	15.1				
	255				71.6	12.5	863	183
5/22/91		1,298	231	17.8				
	109				37.4	6.6	72	85
9/12/91		557	104	18.7				
	273				84.9	21.8	468	156
6/11/92		940	240	25.5				
	341				25.2	6.0	927	277
5/20/93		1,164	298	25.6				
	375				95.1	18.2	86	349
6/01/94		1,188	254	21.4				
	354				32.2	7.1	171	77
5/23/95		553	110	19.9				
	377				37.7	9.2	204	69
6/05/96		411	99	24.1				
	354				69.8	25.1	549	246
5/27/97		821	317	38.6				
	355				29.1	9.9	969	361
5/19/98		1,205	396	32.9				
	375				54.4	10.8	423	367
6/01/99		1,078	254	23.6				

^a Estimate obtained from Parker et al. (1987).

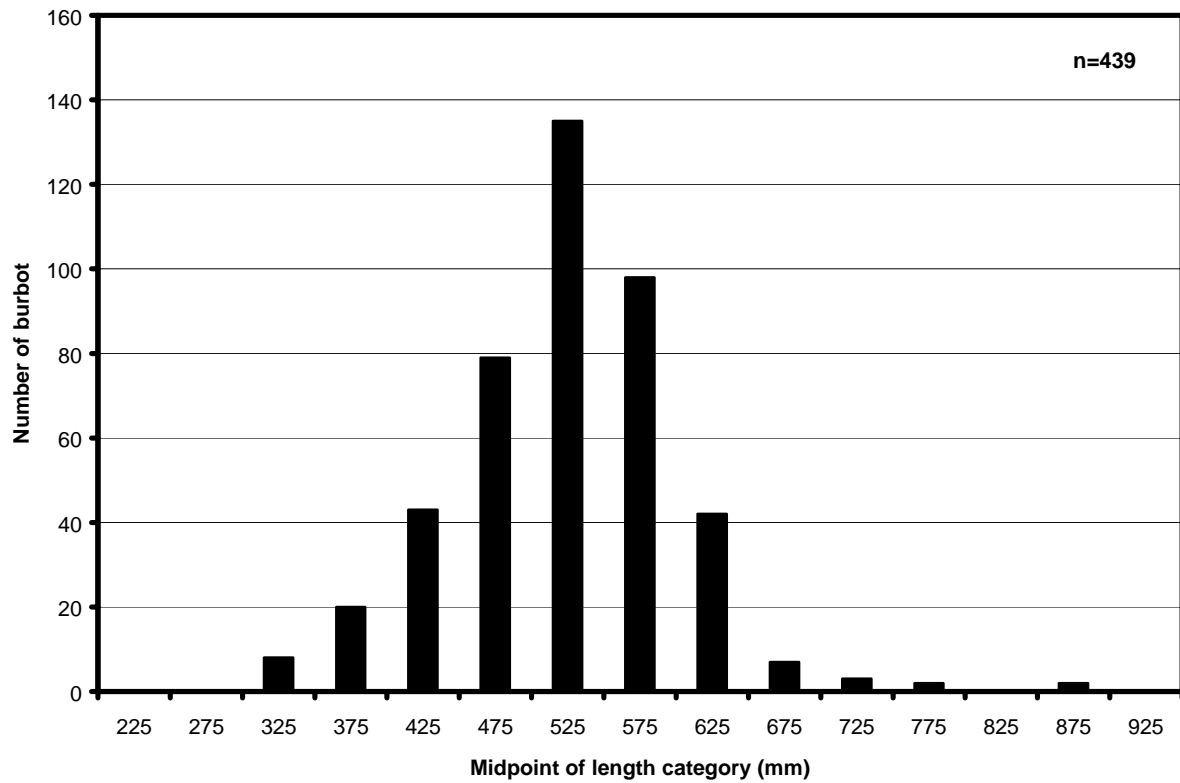


Figure 4.-Length-frequency of burbot captured in Tolsona Lake in 2000.

Table 2.-Estimated abundance and density of fully recruited (≥ 450 mm TL) burbot in Tolsona Lake during 1999.

Lake	Date	Abundance	SE	Area of Lake (ha)	Density (burbot/ha)	SE
1999	June 1-3	1,078	254	130	8.29	1.95

Table 3.-Estimated mean CPUE of fully recruited (≥ 450 mm TL) and partially recruited (< 450 mm TL) burbot in Tolsona Lake, 2000.

Dates	Strata	Sets	Transects	Mean CPUE			Bootstrapped	
				Bootstrapped	Arithmetic	% Δ	SE	CV
<u>6/6-8/00</u>	All depths	59	7					
		Fully Recruited:		6.25	6.24	0.2%	0.74	11.9%
		Partially Recruited		1.098	1.102	-.3%	0.344	31.3%

Table 4.-Historical statistics for Tolsona Lake burbot^b.

Year	Sampling date	N	SE	CPUE	SE	Mean length	SE	Angler-days	Harvest	Catch	Regulation
1983								185	713		15 bag/possession; setlines (Oct. 15 - May 4)
1984								505	1864		15 bag/possession; setlines (Oct. 15 - May 4)
1985								191	1050		15 bag/possession; setlines (Oct. 15 - May 4)
1986	9/26	1901	120	3.98	1.24	501	2	807	1243 ^a		15 bag/possession; setlines (Oct. 15 - May 4)
1986	10/10			7.15	0.68	497	2				
1987	6/4	1291	120	6.15	0.75	496	1	1204	684 ^a		2 bag/possession; setlines (Oct. 15 - May 4); burbot fishery closed 2/6/87
1987	6/25			2.79	0.47	500	4				
1988	5/26	1571	165	5.93	0.83	507	2	1207	73 ^a		2 bag/possession; setlines (Oct. 15 - May 4)
1988	9/1	1280	155	3.58	0.71	520	3				
1989	5/24	1549	176	5.86	0.81	514	2	610	94		5 bag/possession; EO no setlines
1989	9/13	1663	273	4.08	0.50	522	3				
1990	5/24	1340	237	3.59	0.43	515	4	495	408	408	5 bag/possession; EO no setlines
1990	9/7	608	92	2.95	0.33	534	4				
1991	5/22	1298	231	3.62	0.42	505	2	561	108	108	5 bag/possession; BOF setlines prohibited UCUS
1991	9/12	557	104	1.14	0.17	534	5				
1992	6/11	940	240	3.14	0.51	518	4	779	127	203	5 bag/possession
1993	5/20	1164	298	3.83	0.48	526	3	490	21	192	5 bag/possession
1994	6/1	1188	254	3.50	0.41	568	5	981	93	135	5 bag/possession
1995	5/23	553	110	3.44	0.36	612	5	653	23	46	5 bag/possession
1996	6/5	411	99	2.19	0.24	613	8	759	81	93	5 bag/possession
1997	5/27	821	317	0.80	0.14	618	14	160	0	0	5 bag/possession
1998	5/19	1205	396	2.19	0.39	523	9	276	0	0	5 bag/possession; closed by EO
1999	6/1	1078	254	2.57	0.58	524	5	269	0	0	2 bag/possession; closed by EO
2000	6/6			6.25	0.74	547	8	94	0	0	2 bag/possession; closed by EO

^a Harvest estimates were combined in the Statewide Harvest Survey for Moose and Tolsona lakes

^b Data from Mills 1984-1994, Howe et al. 1995, 1996 2000a, b, c, d, Walker et al. 2001, Lafferty et al. 1990-1992, Lafferty and Bernard 1993, Parker et al. 1987-1989, Taube and Bernard 1995, 1999, Taube et al. 1994, 2000.

Table 5.-Critical levels and measurements of water quality by depth and date at Tolsona Lake, 2000.

Measurement	Critical Level ^a	Depth								
		0.0 m	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	3.8 m
April 18										
Temperature (C°)	> 18°C	0.13	0.06	0.59	1.71	2.57	3.44	3.81		
Dissolved Oxygen	< 2.0 ppm	3.17	2.84	2.65	2.36	1.01	0.11	0.00		
PH	< 7 or > 9					No data				
Water clarity						No data				
June 23										
Temperature (C°)	> 18°C	12.58	12.53	12.39	12.30	12.28	12.24	12.22	12.18	12.17
Dissolved Oxygen	< 2.0 ppm	10.71	10.72	10.60	10.60	10.52	10.50	10.56	10.54	1.87
PH	< 7 or > 9	7.63		7.81	7.84	7.89	7.90	7.91	7.93	7.74
Water clarity						2.8				
August 16										
Temperature (C°)	> 18°C	13.26	13.25	13.16	13.16	13.04	13.00	12.99	12.99	
Dissolved Oxygen	< 2.0 ppm	9.20	9.19	9.29	9.10	9.25	9.07	8.86	8.90	
PH	< 7 or > 9	7.38	7.53	7.68	7.84	7.89	7.92	7.97	8.00	
Water clarity						3.5				
October 2										
Temperature (C°)	> 18°C	2.90	2.95	2.87	2.87	2.85	2.84	3.39		
Dissolved Oxygen	< 2.0 ppm	9.67	10.51	10.29	10.30	10.10	10.41	10.38		
PH	< 7 or > 9	7.13	7.37	7.48	7.57	7.71	7.77	7.93		
Water clarity						No data				

^a From Simpson 1997 and Scott and Crossman 1973.

Table 6.-Mean length (mm TL) of burbot measured during sampling events in Tolsona Lake, 2000.

Statistic	Partially Recruited ^a	Fully Recruited	All
Mean	399	547	525
SE	6	8	9
Sample size	65	374	439

^a Burbot partially recruited to the gear were < 450 mm TL and fully recruited burbot were ≥ 450 mm TL.

Estimated length composition of burbot sampled in 2000 was similar to burbot sampled in 1999 (Taube et al. 2000). The 525 mm length category was the predominant size category of burbot captured in 2000 (Figure 4). The mean length of fully recruited burbot was 547 mm (Table 6).

After inspection of statistics on burbot in Tolsona Lake (Table 4), we concluded that no exploitation rate model could be derived at this time. High mortality rates of fully recruited burbot and poor recruitment in the last decade could not have been caused by density-dependent factors. Abundance of burbot in Tolsona Lake remained stable through 1994, then experienced a dramatic decline in 1995 and remained low in 1996 (Figure 3). This decline was attributed to environmental conditions in Tolsona Lake and not high exploitation (Taube and Bernard 1999). Poor summer survival in 1990 and 1991 and poor annual survival in 1992, 1994, and 1995 of fully recruited burbot contributed to the decline (Table 1). In addition, low recruitment occurring in 1994 and 1995 also contributed to the low abundance in 1995 and 1996.

During the 1990's, the Copper River Basin experienced drought conditions and the water level in Tolsona Lake dropped several feet. This likely resulted in water temperatures near critical levels for burbot survival and increased stress in post-spawning burbot. This may have also caused juvenile burbot to move out of the protective covering of the shallow waters and become susceptible to greater levels of predation. Considering that recruitment in 1993 was the first that could be tied back to an estimate of spawning abundance (1987), occurrence of environmental stress in the 1990s confounded the spawner-recruit relationship. During the winter of 1999-2000, the Tolsona Lake drainage experienced heavy snowfalls, which resulted in the water level of the lake returning to normal or above normal levels. It is too soon to know if the higher water level will result in increased abundance of burbot, even though there appears to be an increasing trend in the population since 1997. At this time, the fishery in Tolsona Lake remains closed until the abundance reaches 1,500 burbot > 450 mm.

The recent increase in the abundance of burbot in Tolsona Lake is likely due to a combination of the reduction in harvest (fishery has been closed since March 1998) and favorable environmental conditions. For fully recruited burbot, the 1999 estimate of abundance is more than twice that of the 1996 estimate. Recent years of strong recruitment (1997 and 1998) should contribute to increasing abundance, though poor survival in 1997 may offset this somewhat (Table 1). Water level conditions since spring 2000 should also contribute to higher survival rates and recruitment in the near future since greater water depth results in more favorable water temperatures.

The 1993 age class continues to be the dominant age class (Taube and Bernard 1999; Taube et al. 2000; Figure 4). As this cohort has matured, the proportion of larger burbot has increased. During the lows in abundance in 1995 and 1996, the proportion of larger burbot (> 600 mm) was greater than from 1997 to 2000 when the population was larger. This is a reflection poor survival and recruitment rates during 1995 and 1996.

Given that estimated carrying capacity for this lake is 2,540 fully recruited burbot when there are optimal environmental conditions (see Simpson 1997), maximum production (470 burbot) would be achieved with approximately 1,250 fully recruited burbot or half the maximum biomass (Graham method, Ricker 1975; see Appendix C). A population of 1,500 would provide a buffer of about 250 adults. Once the population of fully recruited burbot reaches 1,500, we expect a restrictive daily bag limit of two burbot per day will provide sustainable harvest levels as long as the ban on set lines is maintained.

Public testimony has indicated a bag limit lower than two per day is not acceptable and would probably result in less participation. The history of fishing at Tolsona Lake has shown that liberal bag limits result in high levels of exploitation and therefore a bag limit > 2 fish is probably not sustainable. This is true especially since burbot are slow to mature and are long-lived. For this reason burbot cannot recover quickly from high levels of exploitation. Add to this unusual or unfavorable environmental conditions that impact survival or recruitment and high levels of exploitation in this fishery are not sustainable.

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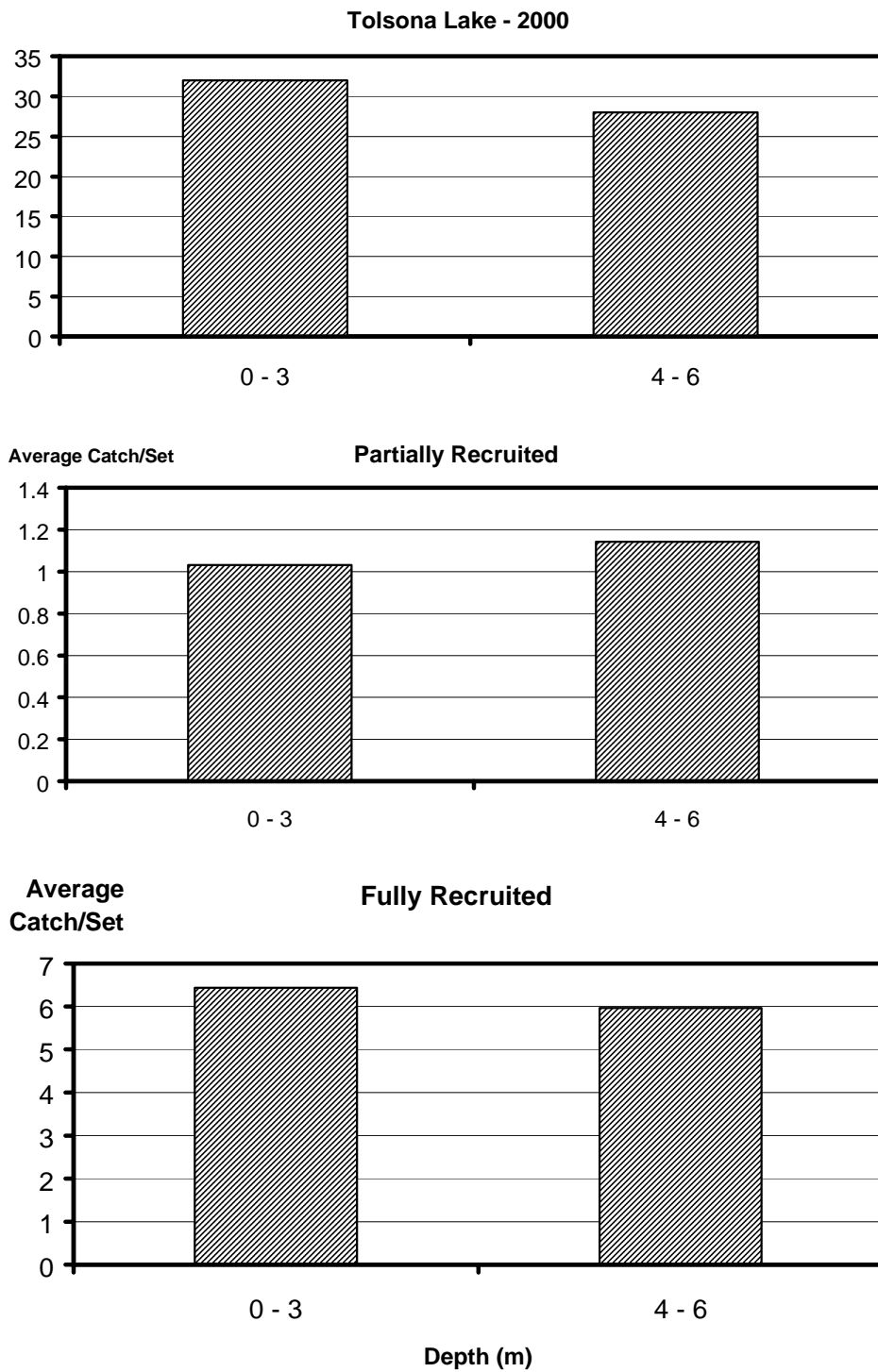
APPENDIX A

Appendix A1.-Mark-recapture histories of fully recruited (≥ 450 mm TL) burbot by year for the population in Tolsona Lake.

Tolsona Lake																			
Date : Year	1986	1987	1988	1988	1989	1989	1990	1990	1991	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Beginning	9/23	6/02	5/25	8/30	5/22	9/11	5/22	9/05	5/20	9/09	6/11	5/20	6/01	5/23	6/05	5/27	5/19	6/01	6/06
Ending	10/10	6/04	5/27	9/01	5/24	9/13	5/24	9/07	5/23	9/12	6/13	5/22	6/03	5/25	6/07	5/29	5/21	6/03	6/08
Number of Fully Recruited Burbot:																			
Recaptured from Event 1	0	123	35	14	5	3	5	9	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 2		0	79	32	33	18	11	5	1	1	0	0	0	0	0	0	0	0	0
Recaptured from Event 3			0	51	36	13	11	8	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 4				0	45	13	4	5	3	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 5					0	63	14	8	10	2	0	0	0	1	0	0	0	0	0
Recaptured from Event 6						0	22	9	5	2	0	0	0	0	0	0	0	0	0
Recaptured from Event 7							0	21	15	2	2	0	0	1	0	0	0	0	0
Recaptured from Event 8								0	33	7	8	2	1	0	0	0	0	0	0
Recaptured from Event 9									0	35	14	8	1	0	1	0	0	0	0
Recaptured from Event 10										0	27	3	3	1	0	0	0	0	0
Recaptured from Event 11											0	6	7	6	0	1	1	0	0
Recaptured from Event 12												0	39	17	7	2	0	0	0
Recaptured from Event 13													0	27	3	2	0	0	0
Recaptured from Event 14														0	29	3	2	0	1
Recaptured from Event 15															0	11	6	3	1
Recaptured from Event 16																0	6	5	0
Recaptured from Event 17																	0	24	27
																		0	37
																			0
Captured with tags	0	123	114	97	119	110	67	65	67	49	51	19	51	53	40	19	15	32	66
Captured without tags	531	379	236	118	239	139	148	115	296	88	145	210	159	149	111	96	264	163	373
Captured	531	502	350	215	358	249	215	180	363	137	196	229	210	202	151	115	279	195	439
Released with tags	531	497	350	215	358	249	215	180	362	136	196	225	209	198	129	104	279	195	438

APPENDIX B

Appendix B1.-Frequency of sets by depth and average catch of burbot by depth in Tolsona Lake in 2000.



APPENDIX C

Appendix C1.-Calculation of Maximum Sustained Yield of burbot in Tolsona Lake at carrying capacity.

If S is the annual survival rate with no fishing (as is the case from May to May 1998-9 during which S was estimated at 54%), the instantaneous natural mortality rate (Gulland 1985) is:

$$M = -\ln(S) = 0.61$$

From Gulland (1985), the empirical relationship between natural mortality and the intrinsic rate of increase (r) is:

$$r = 4(0.3)M = 0.74$$

Given a carrying capacity K of 2,540 large burbot and logistic surplus production:

$$MSY = \frac{rK}{4} = 470$$

A parametric bootstrap based solely on the sampling error for S (10.8%) gives an estimate for SE_{MSY} at 161 with 1000 draws from a normal distribution. The estimate of SE_{MSY} is considered a minimum.
